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Market Integration of Wheat in Pakistan

von

Jam Ghulam Murtaza Sahito[a,b]

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[a] Center for International Development and Environmental Research (ZEU), Senckenberg Strasse 3, 35390, Giessen, Justus Liebig University Giessen, Germany

[b] Department of Agricultural Economics, Sindh Agriculture University Tando Jam, Sindh, Pakistan.

Email: sahito@sau.edu.pk ; Murtaza.Sahito@zeu.uni-giessen.de ; jamabid@yahoo.com

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ABSTRACT: Understanding market integration in developing countries is an important issue in current research. This study is an attempt to analyze wheat market integration in Pakistan. Previous research on the subject has attempted at analyzing market integration in Pakistan's south and north Punjab regions, mainly relying on co-integration only and not considering advanced dynamic models and transaction costs to analyze the degree of integration. Therefore, this study is a first attempt to analyze the extent of market integration in the whole country using a dynamic model. Monthly wholesale price data of five regional markets from January 1988 to April 2011 are used for this study. Price series were tested for stationarity with the Augmented Dickey Fuller (ADF) test and it was found that all prices are integrated of order one, commonly written as I(1). Co-integration was also identified in all price series pairs using Johansen's co-integration test. The Vector Error Correction Model (VECM) was then applied to the data to analyze the extent of market integration. As a result, it was found that the adjustment to shocks or disequilibrium was higher for the Lahore and Rawalpindi markets as compared to the Hyderabad and Peshawar markets. It might be because of the high consumption, low production and developed infrastructure in these regions. Adjustment coefficients were significant for most of the market pairs. The Threshold Vector Error Correction Model (TVECM) with a band of non-adjustment was applied to incorporate transaction costs, without relying on observations for these costs, which were not available for the study. It was found that linear ECMs or VECMs provide misleading results as compared to TVECMs. Short-run adjustments in the TVECM model provide mixed results depending on regimes as well as markets. Strong adjustments were found in the upper regime, which shows that when price differences are above the second threshold markets tend to adjust significantly.

Keywords: Market integration, co-integration, wheat, commodity prices, error correction, thresholds.

JEL-Classification: C32; F15

1 Introduction

Market integration describes the degree of price transmission within vertically or geographically separated markets. Spatial or vertical market integration of homogenous commodities especially in developing countries has been the center of interest for economists in the last few decades. Special attention has typically been given to basic food crops such as wheat and rice, because food insecurity is a major issue for developing countries. Market integration studies in agriculture, especially for developing countries are the tools to examine, evaluate, regulate and reform price polices for food security and price stability.

In the context of Pakistan, a developing country, wheat is the major food crop, providing the largest source of calorie intake, thus it is important from food security perspective. The World Trade Organization (WTO) considers Pakistan as the most food insecure among net wheat importing developing countries (GoP 2011-2012). Pakistan has not yet achieved self-sufficiency, especially in wheat production, and has remained largely a net importer of wheat. In fact, Pakistan has only exported a small amount of wheat as a result of bumper crop between the years from 2000 to 2006. Overall, the production of wheat has been volatile in Pakistan during the last two decades (GoP 2011-2012).

Price transmission among domestic markets will enable us to understand the vulnerability of the population to food market shocks in Pakistan. Market integration studies provide valuable information about the efficiency of market functioning and about the dynamics of price adjustment in the markets. Information of spatial market integration infer the efficiency of pricing, effectiveness of arbitrage and competitiveness of markets, which implies the efficient market functioning (Sexton *et al.* 1991).

There are many hindrances to the efficient functioning of the agricultural commodities market in Pakistan. Some major issues include insufficient transportation infrastructure, restrictions on the movement of wheat within provinces and districts, no or sparse access to market information, market structure and changes in the costs of production (Tahir and Riaz 1997). For example, intra-province movement restriction of wheat in the months of harvesting and support price policy of wheat are direct interventions of the government. Transportation infrastructure, information and communication are other factors affecting market integration.

The government of Pakistan has been involved in interventions within the wheat sector via support prices, procurement, storage, transportation and distribution of wheat to flour millers since independence. Two major objectives of this intervention are, first, to protect consumers from higher import prices, and second, to protect producers via procurement and support prices in an effort to reduce price volatility (Ahmed *et al.* 2006). The government of Pakistan procures about 25 to 30 percent of total wheat production every year (GoP 2011-2012). These government interventions are considered as the fiscal burden on the economy in case of higher degree of market integration (Mushtaque *et al.* 2007 and Dorosh and Salam 2008). Higher degree of market integration and quicker adjustment of prices to form a new equilibrium as a result of shocks to the market prices also explains the efficient functioning of markets. Hence, it is worthwhile to assess the degree of market integration of wheat markets in Pakistan.

There are only few market integration studies regarding the food markets of Pakistan. Unfortunately, most of them have focused only on one or two regions of Punjab province and relied on co-integration coefficients or error correction mechanism only. There has been a lot of development in the last two decades regarding the methods to investigate market efficiency and integration, which has not been applied to food markets of Pakistan.

Many models and methods have been developed to analyze integration of markets. Every method has its own strengths and weaknesses. However, due to intuitive interpretation, error correction models have gained the attention of the majority of studies. Most of these studies rely only on time series data of prices and do not take into account transaction costs or trade flows. A brief review about these studies is provided in section two.

Although, Barrett (1996) and Barrett and Li (2002) are of the opinion that one cannot describe spatial market relationships only by prices but by their combination with transaction costs. However, transaction costs are neither easily available nor can any other proxy be used to incorporate these costs. Threshold models estimate a neutral band linked with unobservable transaction costs and stretch explicit attention to these costs. Therefore, a threshold vector error correction model (TVECM) will be used for analysis, by using a band of non-adjustment (Thresholds) to consider a band of no arbitrage. These models recognize the size of the band or their thresholds in response to shocks to horizontally separated markets prices. This is, however, conditional on, if the shock is substantial enough to raise price differentials between two separated markets above the transaction cost.

To the best of my knowledge, there have been no such studies analyzing market integration of wheat within different regions (Provinces) of Pakistan using advanced dynamic models. Therefore, a through market integration analysis of wheat in Pakistan based on information of the degree of market integration will assist the government in formulating policies to provide infrastructure and information services in an effort to avoid market exploitation. Keeping in mind the importance of market integration for an efficient marketing system, this paper aims to analyze the degree of market integration with the help of a dynamic model.

The remainder of this paper is as follows: Section 2 contains a review of previous studies including their strengths and deficiencies. Section 3 clarifies the methodology. Results will be presented in section 4. Section 5 will provide some conclusions.

2 Review of Literature

Overall market performance of the agricultural products is the result of market integration (Faminow and Benson 1990). Trading markets at two different locations are spatially integrated if price changes in one market are reflected in the prices of the other market (Goodwin and Schroeder 1991). If the spatial markets are strongly integrated, differences between the local prices in regional markets will be equal to transportation and transaction charges only. Thus, competitiveness and efficiency of pricing are the results of spatial market linkages/ integration (Sexton *et. al.* 1991). In case of less integrated spatial markets, distorted price signals leading to inefficient resources use, result in inefficient marketing (Goodwin and Schroeder 1991). The nature of markets, working capabilities and their role in price determination is key for the allocation and optimization of resources and thus for the resource productivity (Sexton *et al.* 1991).

The history of market integration studies began nearly a century ago, but in the last 20 to 30 years research on market integration has increased tremendously, and has seen even more momentum in recent years. The first market integration studies mostly relied on correlation coefficients, for details see Jasdanwala (1966), Farruk (1970), Jones (1972), Lele (1972) and Blyn (1973). Due to their static nature, recent studies have criticized and rejected these techniques. More contemporary market integration studies have identified various measures including short and long-term tests of integration by Ravallion (1986). Many authors have since studied co-integration coefficients and have concluded that integrated spatial markets exhibit an equilibrium relationship, some of these authors include Ardeni (1989), Goodwin and Schroeder (1991), Palaskas and Harriss (1991), Sexton *et al.* (1991) and Gonzalez and Helfand (2001).

Some studies have compared various market integration measures and analyzed the structural factors affecting these measures, which include Goodwin and Schroeder (1991), Faminow and Benson (1990) and Goletti *et al.* (1995) linked market integration with structural factors or determinants. Regression and co-integration based tests have also been criticized recently for their ignorance of transaction costs by Barrett (1996), Balke and Fomby (1997), Baulch (1997), McNew and Fackler (1997), Fackler and Goodwin (2001), Barrett and Li (2002), Hansen and Seo (2002) and Goodwin and Piggott (2001) who introduced threshold co-integration.
Bekkerman *et al.* (2013) further extended threshold models by incorporating time-dependent market linkages conditional on changes in numerous exogenous economic and biological factors; two major factors used were fuel prices and seasonality components. They also compared constant and variable transaction cost threshold band models and found that variable threshold models reveal a better statistical fit and statistically significant effects of time-dependent exogenous factors on market linkage variations. Meyer (2004) argues that without directly relying upon transaction costs, which are often not available as time series, threshold models of price transmission can account for the effects of these costs. He emphasized that results of two- thresholds models are economically more intuitive as compared to one-threshold models.

Ejrnaes and Persson (2000) applied threshold error correction models to French wheat prices and argued that adjustments to price differentials only take place when deviations between different market prices exceed some threshold or transaction costs. The authors estimated the transport costs and found that estimates were very close to actual observed costs. Further, they claimed that estimates for speed of adjustment were more accurate in the threshold model.

The only relevant study of market integration regarding food markets of Pakistan comes from Mushtaque *et al.* (2007), who studied the wheat markets of Pakistan. Other studies, including Kurosaki (1996), Mushtaque *et al*. (2008), Tahir and Riaz (1997) and Zahid *et al*. (2007) limited their studies to the Punjab province of Pakistan. Some of them have focused on either southern or northern regions of Punjab, or on different commodities like cotton, gram, rice and fruits and vegetables. All of them have restrained themselves to co-integration, and not a single author has used threshold models to analyze integration of markets.

Zahid *et al.* (2007) tested spatial market integration in different wheat markets in Northern Punjab, Pakistan. They applied the Engle and Granger test of co-integration to analyze long-run market integration between Lahore as a central market and five other markets of Northern Punjab. They found some markets only partially integrated because of long distance, lesser information flow and different socio-economic conditions.

Tahir and Riaz (1997) tested integration of agricultural commodity markets of cotton, wheat, and rice in southeastern Punjab. The author applied an analytical framework introduced by Ravallion (1986), in which it is possible to test for short-run and long-run integration or complete market segmentation. They concluded that cotton, wheat and rice markets in southeastern Punjab are well integrated in the long-run only. In a few special cases, short-run integration was significant. While, Mushtaque *et al.* (2007) analyzed the same prices series of wheat markets, which are covered here, and concluded on the basis of co-integration tests that except Peshawar, the remaining four markets Hyderabad, Lahore, Multan and Rawalpindi are well integrated.

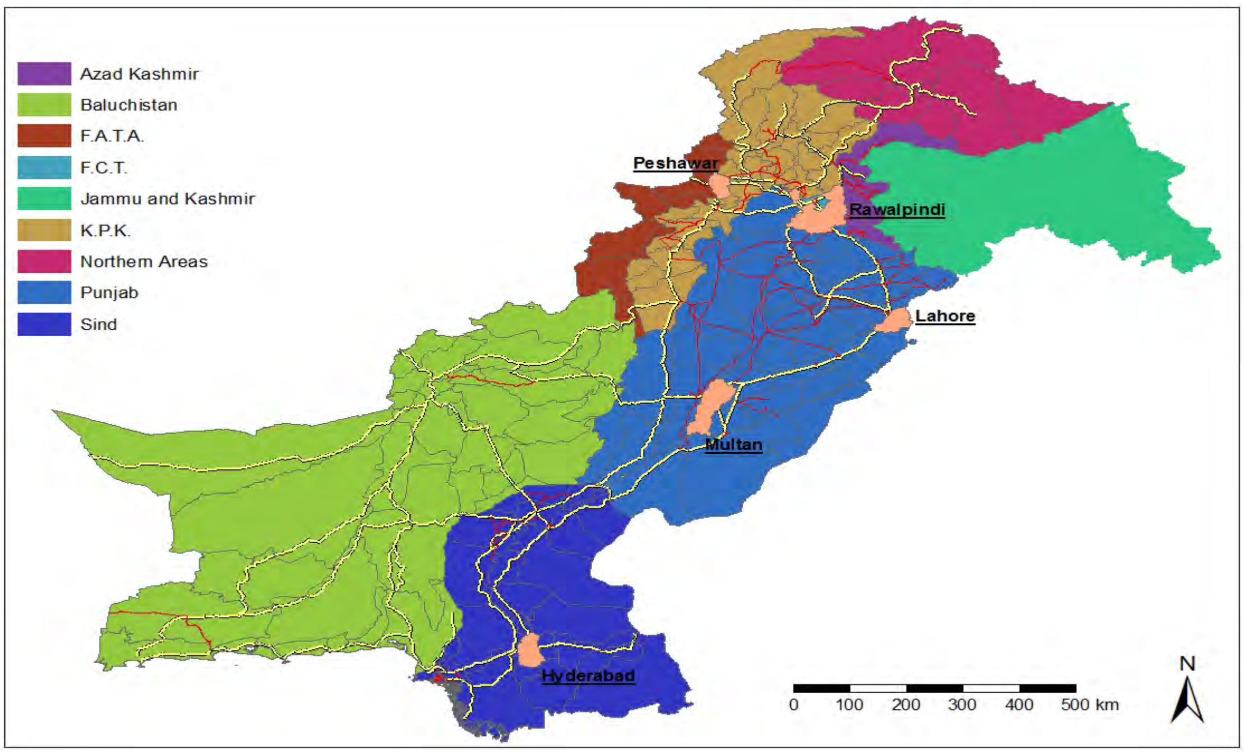
3 Data and Methods

This section provides the information about the data used in this study and the methodology used to analyze the data.

3.1 Data

The five wholesale wheat markets selected for the study are Hyderabad from Sindh Province, Lahore, Multan, and Rawalpindi from Punjab province and Peshawar form Khyber Pakhtunkhwa Province. A map of Pakistan is given below, indicating the markets selected for the study.

Figure-1: Map of Pakistan Indicating Selected Wheat Markets.



Source: own illustration using GIS program and data from http://www.gadm.org/

Monthly wholesale price series of the selected markets, from January 1988 to April 2011 (280 observations), have been selected in this study, due to unavailability of the data afterwards. The unit of the price is rupees per 40 kg. Three markets have been chosen from Punjab province because Punjab is the largest producer of wheat in Pakistan. Punjab contributes about 75 percent of the total production of wheat in Pakistan. No markets from Baluchistan are included as time series data are not available and very low production. As Punjab is the largest contributor to overall production of the country as well as the largest province in terms of population, it is also the biggest province in terms of consumption. The above-mentioned data is available in Agricultural Statistics of Pakistan 2010-11 issued by Pakistan Bureau of Statistics (GoP 2010-11).

3.2 Methodology

In the context of standard regression, stationarity of the time-series variables naturally becomes an issue. Thus, the Augmented Dickey Fuller unit root test, commonly known as ADF test developed by Dickey and Fuller (1979, 1981) to investigate the presence of unit roots (non-stationarity) in the individual time series of prices, has been performed. If two non-stationary time series variables are integrated of the same order I(d), then a linear combination of those two non-stationary variables might be stationary. This implies that the variables are co-integrated (Engle and Granger 1987). A co-integrated process exhibits non-stationarity with both long-run equilibrium and short-run relationships. This is a solution to spurious regressions. Two major co-integration methods, extensively and consistently used in the econometric literature, are (i) the Engle and Granger's two-step method and (ii) the Johansen maximum likelihood method. To test the pair-wise as well as joint co-integration between different prices series, the Johansen (1988) method of maximum likelihood is used in this study, mainly because of shortcomings of Engle-Granger approach. Except that it relies on a two-step method, the order of the variables in the regression in the first step is also an important issue (Asteriou and Hall 2007, Ch. 17, pp. 315-321). Further, we cannot test for multiple co-integrating vectors with this approach like with the Johansen method. Another advantage of using the Johansen method is that one can test hypotheses on the co-integration relationship itself (Brooks 2008, Ch. 8, pp. 318-365).

In market integration models, except a few studies on Parity Bound Models (PBM) presented by Baulch (1997) and Barrett and Li (2002), most of the empirical studies applied Vector Error Correction models, because of their easy and intuitive interpretation. In Parity Bound Models, there are three possible trade regimes: at the parity bound, inside the parity bond, outside the parity bond attributed as regimes I, II and III. In these regimes, the price differential between two locations is exactly equal to transaction costs, the difference of prices between two locations is lower than transaction costs and the price difference is higher than the transaction costs, respectively. PBM has been subject to criticism due to a few limitations. First, as only contemporaneous spreads are used in its estimation, it is difficult for the model to consider the lagged price adjustment. Second, transfer costs are included explicitly in the notion of spatial equilibrium, if transfer costs data are not available the PBM requires an assumption about the evolution of transfer costs over time. It is crucial that transfer costs should be estimated as precisely as possible because the estimates of regime probabilities in the model are only as good as the estimate of mean transfer costs used to separate regimes. In principal, VECM is a re-parameterization of Vector Autoregressive (VAR) models. Fundamentally, VECM uses lagged values of the time series in relation to current price change.

A bivariate VECM Model can be defined as:

$$\begin{bmatrix}\Delta P_{1t}\\ \Delta P_{2t}\end{bmatrix} = \begin{bmatrix}\alpha_1\\ \alpha_2\end{bmatrix} + \sum_{i=1}^{k}\begin{bmatrix}\beta_i^{P_1,P_1} & \beta_i^{P_1,P_2}\\ \beta_i^{P_2,P_1} & \beta_i^{P_2,P_2}\end{bmatrix} \times \begin{bmatrix}\Delta P_{1t-1}\\ \Delta P_{2t-1}\end{bmatrix} + \begin{bmatrix}\varphi_1\\ \varphi_2\end{bmatrix}[ECT_{t-1}] + \begin{bmatrix}\varepsilon_{1t}\\ \varepsilon_{2t}\end{bmatrix} \qquad \textbf{(1)}$$

Where: $\Delta P_t = P_t - P_{t-1}$, P_1 is the price series in one market and P_2 is the price series in the other.

VECM is different from VAR in the sense that it separates the long-run relationship (co-integration coefficients) from short-run adjustments that describe the correction of price to disequilibrium. In this model, φ_i coefficients describe the long-run reaction of prices to disequilibrium, while, $\boldsymbol{\beta_i}$ are adjustment parameters for lagged short-run dynamics. If the two price series are co-integrated than φ_1 must be negative.

Hassouneh *et al.* (2012) describe two restrictions of VECM. First, parameters of VECM are linear, as they are assumed the same over the whole period under study. Second, a linearity restriction is described based on the linear reaction of dependent variables subject to changes in the independent variables. Many studies have emphasized the deviations from one or both forms of linearity in different applications of market integration (Greb *et al*. 2012; Hassouneh *et al*. 2012; Meyer and von Cramon-Taubadel 2004).

Parameters of price transmission between two spatially separated markets having variable transportation costs cannot be fixed over time. In this case, the first type of linearity is a very hard restriction. Barrett and Li (2002) describe the difficulties in observing all possible transaction costs, like: trade flows, risk assessment, discount rates and other possible costs. They also implied the possibility of trade and adjustment of short-run prices due to arbitrage, if the difference between two market prices is higher than the transaction cost, because of the unobservable costs, policy interventions and different strategies. Hence, if the price difference is less than a certain threshold, there is no arbitrage benefit for traders.

Balke and Fomby (1997) introduced the concept of threshold co-integration, based on discontinuous long-run equilibrium adjustments. This concept allows addressing the above-mentioned criticism on linear co-integration and justifies the use of threshold models for price adjustment. In particular, this model allows for a no-arbitrage band. Adjustments only occur, when the deviations in the long-run equilibrium are greater than transaction costs or a particular threshold, where the error-correction term determines the threshold parameter. As the TVECM is a special form of asymmetric VECMs, price adjustment can be different depending on the regimes. This model is extendable, by incorporating constants or intercepts and lags in each regime. Regime-switching models have attracted several researchers of price transmission analysis, and have been extended and applied by many researchers such as, Lo and Zivot 2001; Goodwin and Piggott 2001; Hansen and Seo 2002; Meyer 2004; and Seo 2006.

A bivariate TVECM Model with two thresholds (three regimes) can be defined as:

$$\begin{bmatrix}\Delta P_{1t}\\ \Delta P_{2t}\end{bmatrix} = \begin{bmatrix}\alpha_1\\ \alpha_2\end{bmatrix} + \sum_{i=1}^{k}\begin{bmatrix}\beta_i^{P_1,P_1} & \beta_i^{P_1,P_2}\\ \beta_i^{P_2,P_1} & \beta_i^{P_2,P_2}\end{bmatrix} \times \begin{bmatrix}\Delta P_{1t-1}\\ \Delta P_{2t-1}\end{bmatrix} + \begin{bmatrix}\varphi_1\\ \varphi_2\end{bmatrix}[ECT_{t-1}] + \begin{bmatrix}\varepsilon_{1t}\\ \varepsilon_{2t}\end{bmatrix}, if\ \ ECT_{t-1} \leq \gamma_1$$

$$\begin{bmatrix}\Delta P_{1t}\\ \Delta P_{2t}\end{bmatrix} = \begin{bmatrix}\alpha_1\\ \alpha_2\end{bmatrix} + \sum_{i=1}^{k}\begin{bmatrix}\beta_i^{P_1,P_1} & \beta_i^{P_1,P_2}\\ \beta_i^{P_2,P_1} & \beta_i^{P_2,P_2}\end{bmatrix} \times \begin{bmatrix}\Delta P_{1t-1}\\ \Delta P_{2t-1}\end{bmatrix} + \begin{bmatrix}\varphi_1\\ \varphi_2\end{bmatrix}[ECT_{t-1}] + \begin{bmatrix}\varepsilon_{1t}\\ \varepsilon_{2t}\end{bmatrix}, if\ \gamma_1 \leq ECT_{t-1} \leq\ \gamma_2$$

$$\begin{bmatrix}\Delta P_{1t}\\ \Delta P_{2t}\end{bmatrix} = \begin{bmatrix}\alpha_1\\ \alpha_2\end{bmatrix} + \sum_{i=1}^{k}\begin{bmatrix}\beta_i^{P_1,P_1} & \beta_i^{P_1,P_2}\\ \beta_i^{P_2,P_1} & \beta_i^{P_2,P_2}\end{bmatrix} \times \begin{bmatrix}\Delta P_{1t-1}\\ \Delta P_{2t-1}\end{bmatrix} + \begin{bmatrix}\varphi_1\\ \varphi_2\end{bmatrix}[ECT_{t-1}] + \begin{bmatrix}\varepsilon_{1t}\\ \varepsilon_{2t}\end{bmatrix}, if\ \ ECT_{t-1} \geq \gamma_2$$

(2)

Here, γ_1 and γ_2 are the threshold parameters. P_1 and P_2 represent the prices in two markets respectively. The autoregressive parameters differ, based on regimes, whether the variables are below, between two regimes or above the higher threshold. These models have three regimes, namely, lower, middle and higher. Each regime should contain at least 5 to 15 percent of all observations for the empirical application following Goodwin and Piggott (2001), Hansen and Seo (2002) and Meyer (2004). Estimation of this model takes place with a two-dimensional grid search over the thresholds and co-integrating values based on maximum likelihood estimator using "tsDyn" package in R developed by Stigler (2010).

To test for threshold effects, the SupLM (Supremum Lagrange Multiplier) test developed by Hansen and Seo (2002) has been used, setting the null hypothesis of linear co-integration against the alternative hypothesis of threshold co-integration. This test uses the co-integration coefficient parameter from the linear VECM representation and applies a grid search over the threshold parameter. Critical values and the p-values are generated by a fixed regressor bootstrap method. The advantage of this method is that LM-like statistics allow for heteroskedasticity of unknown form in the same way as White's consistent heteroskedastic standard errors, hence it achieves the correct first-order asymptotic distribution. The Sup LM test statistic can be denoted as:

$$SupLM = \sup_{\gamma L \leq \gamma \leq \gamma U} LM(\widetilde{\beta}, \gamma) \qquad \textbf{(3)}$$

Where $\widetilde{\beta}$, co-integration value is β estimated and γ is the threshold parameter. γL is the trimming parameter (π_0) of the constraint set for the number of observations below the threshold parameter and γU is $(1 - \pi_0)$ number of observations above the threshold. The restriction for the number of observations in the regimes (trimming parameter) must satisfy the following expression.

$$\pi_0 \leq P(ECT_{t-1} \leq \gamma) \leq 1 - \pi_0 \qquad \textbf{(4)}$$

In this analysis, π_0 is equal to 0.10, as Andrew (1993) recommends that the value of π_0 should range from 0.05 to 0.15. Further, 5000 bootstrap replications are used in the analysis to calculate asymptotic critical values and the p-values for the test.

4 Results

This section reveals the estimated results of co-integration, VECM and TVECM models. Before presenting the results, it is important to show the contribution of provinces in the wheat production of the country. This is meant to provide an idea regarding the trade flow of wheat within the different provinces of Pakistan. Table (1) presents area and production of wheat crop in Pakistan (province wise). The statistics depicts that in the cropping year 1987-88, 7308.4 thousand hectares were sown, producing 12675 thousand tonnes of wheat. Both the area under wheat crop as well as production increased in the last twenty-five years, however, area increased only by over one thousand hectares, while production almost doubled until the year 2011-12 as compared to 1987-88.

Table 1: Area and Production of Wheat Crop in Pakistan and Provinces in the Years 1987-88 and 2011-12. Area in 1000 Hectares and Production in 1000 Tonnes.

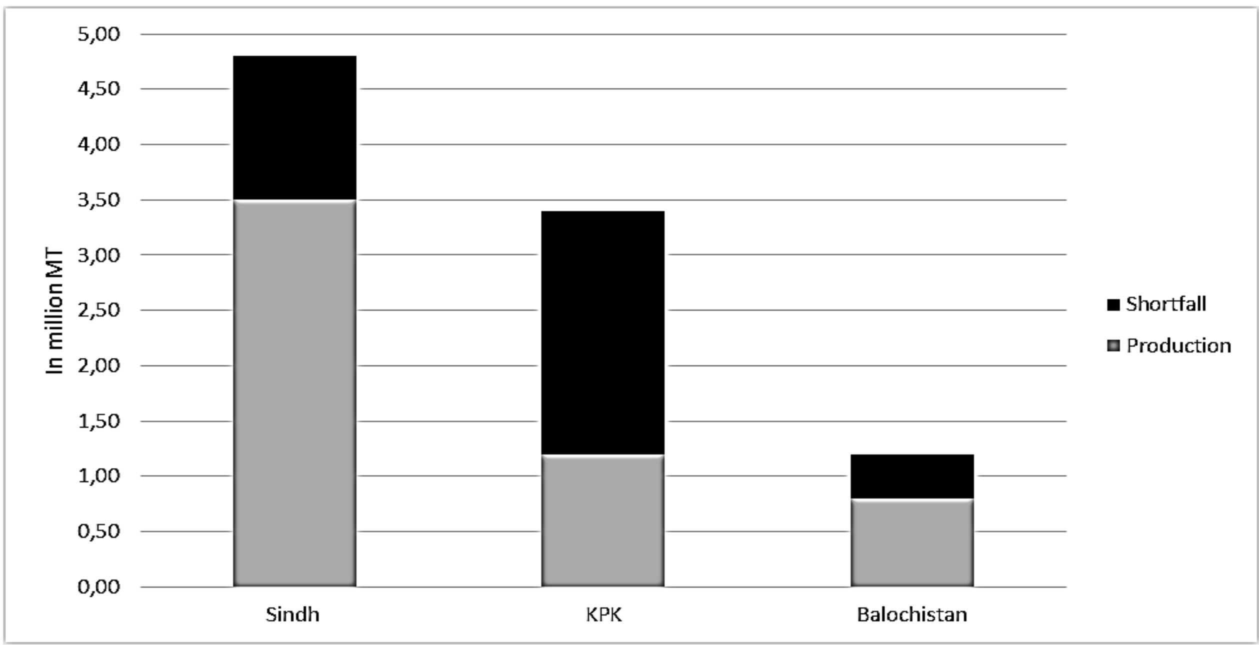
Particulars	**1987-88**		**2011-12**	
	Area	**Production**	**Area**	**Production**
Pakistan	7308.40	12674.40	8649.80	23473.40
Punjab	5343.80 (73 %)	9203.80 (73 %)	6482.90 (75 %)	17738.90 (75 %)
Sindh	1024.80 (14 %)	2180.40 (17 %)	1049.20 (12 %)	3761.50 (16 %)
KPK	756.50 (10 %)	899.20 (7 %)	729.30 (8 %)	1130.30 (5 %)
Baluchistan	183.30 (3 %)	391.00 (3 %)	388.40 (5 %)	842.70 (4 %)

Source: Agricultural Statistics of Pakistan, 1987-88 and 2011-12.

Contributions of the provinces in area and production show that Punjab is and was the single largest contributor in terms of production of wheat as well as in the area sown under wheat. Punjab alone contributed 73 percent of area and production in the year 1987-88. This share increased to 75 percent until the year 2011-12. Area and production of Punjab in the year 2011-12 was 6482.90 and 17738.90 respectively. Area sown in Sindh, KPK and Baluchistan in the year 2011-12 was 1049.20, 729.30 and 388.40, respectively, and production in the same year was 3761.50, 1130.30 and 842.70, respectively. The percentage share of Sindh and KPK in area sown under wheat crop, as well as, production has decreased over the last two decades.

Wheat provides the single largest source of calories in Pakistan, more than 35 percent of the total energy requirement in the country. However, Pakistan has remained largely a net importer of wheat during most of the last twenty-five years, with a small exporting period between the years 2000 to 2006 (GOP 2010-11). Unfortunately, historical data of wheat consumption are not available as readily as data on production. Province wise consumption requirements data are especially difficult to find. As this paper focuses on regional market price series of wheat from different provinces, it is therefore necessary to have an idea of the demand in different provinces. Due to the aforementioned data availability constraint, shortfall of wheat for the year 2008 is presented here to give an idea of wheat deficient provinces (Figure 2). As it turns out, Punjab is the only province of Pakistan having a surplus in wheat production, producing about 16-17 million MT of wheat every year with a consumption requirement of 12.5 million MT in the province.

Figure 2: Wheat Production and Shortfall Province-wise for the Year 2007-08.



Source: UN inter-agency assessment report 2008.

Furthermore, Sindh, Balochistan and Khyber Pakhtunkhwa (KPK) provinces are deficient in wheat production hence trade takes place more from Punjab to these provinces. In most cases, government transports wheat from the stock of wheat procured during the harvest season or finances the private sector to transport to the wheat-deficit areas of the country, to offset the costs of transportation. Sindh has a wheat production shortfall mainly because its capital Karachi, which comprises of dense urban population, is also the main port where imports arrive. The urban population of Karachi are the primary wheat import consumers. KPK is the largest wheat deficit province requiring the allocation of more than two million MT annually. These provinces buy wheat either from PASSCO or from the Punjab food department. KPK shares the porous border with Afghanistan and a large share of wheat is sent to Afghanistan as informal trade rather than reaching local consumers. (UN inter-agency assessment report 2008)

4.1 Unit Root Test Results of Wheat Prices

Results of the Augmented Dickey Fuller (ADF) test for logged price series of five regional markets of wheat in Pakistan at levels and at first differences are presented in Table (2). These results indicate that the null hypothesis of a unit root in all the five markets cannot be rejected for the levels, because the ADF statistics were not smaller than the critical value at the 5 percent significant level provided by Dickey and Fuller (1981). To check the stationarity in the price series at first differences, the ADF test was re-applied to the differenced price series. The ADF statistics indicate the rejection of the null hypothesis of a unit root significantly, implying that all of the price series are stationary at first differences.

Table 2: Unit root test results of logged monthly wholesale prices of wheat markets:

Markets	**Levels**	**1st Difference**
Hyderabad	-0.176	-14.413***
Lahore	0.110	-12.821***
Multan	-0.218	-12.415***
Peshawar	-0.470	-13.936***
Rawalpindi	-0.096	-13.706***

Critical values: 1% level 5% and 10% respectively are -3.454, -2.872, -2.573

Source: Author's own calculations

Since the results indicate that the price series of the wheat markets under study are first-difference stationary, one can infer that all five series are integrated of order one, i.e I(1). Thus, co-integration tests can be applied to see whether there are long run relationship between the markets.

4.2 Co-integration test results

Pair-wise co-integration test results for selected wheat markets are presented in Table 3. Results clearly indicate the existence of a long-run equilibrium relationship between all the pairs of regional wheat markets. Both trace statistics and maximum eigenvalue statistics suggest a co-integration relation in all the ten pairs of five markets. It can be concluded that there is a strong long-run relationship between wheat markets of Pakistan.

Table 3: Pair-Wise Cointegration Test Results Logged Wheat Market prices:

Market Pairs	Null Hypothesis	Alternate Hypothesis	Trace Statistics	Maximum Eigenvalue Statistics
LogLahore-LogHyd	r=0 r≤1	r≥1 r≥2	41.284 (15.494)*** 0.033 (3.841)	41.251 (14.264)*** 0.033 (3.841)
LogLahore-LogMultan	r=0 r≤1	r≥1 r≥2	32.892 (15.494)*** 0.000 (3.841)	32.891 (14.264)*** 0.000 (3.841)
LogLahore-LogPindi	r=0 r≤1	r≥1 r≥2	54.744 (15.494)*** 0.000 (3.841)	54.744 (14.264)*** 0.000 (3.841)
LogLahore-LogPeshawer	r=0 r≤1	r≥1 r≥2	16.853 (15.494)*** 0.014 (3.841)	16.838 (14.264)*** 0.014 (3.841)
LogHyd-LogMultan	r=0 r≤1	r≥1 r≥2	40.627 (15.494)*** 0.029 (3.841)	40.598 (14.264)*** 0.029 (3.841)
LogHyd-LogPindi	r=0 r≤1	r≥1 r≥2	38.019 (15.49)*** 0.026 (3.841)	37.992 (14.264)*** 0.026 (3.841)
LogHyd-LogPeshawer	r=0 r≤1	r≥1 r≥2	22.452 (15.494)*** 0.068 (3.841)	22.383 (14.264)*** 0.068 (3.841)
LogMultan-LogPeshawer	r=0 r≤1	r≥1 r≥2	15.731 (15.494)** 0.020 (3.841)	15.710 (14.264)** 0.020 (3.841)
LogMultan-LogPindi	r=0 r≤1	r≥1 r≥2	43.079 (15.494)*** 0.003 (3.841)	43.076 (14.264)*** 0.003 (3.841)
LogPindi-LogPeshawer	r=0 r≤1	r≥1 r≥2	15.984 (15.494)** 0.016 (3.841)	15.967 (14.264)** 0.016 (3.841)

Critical values at 95% confidence interval are in parenthesis.

Source: Author's calculations

Table 4 presents the results of joint co-integration tests for all five wheat markets of Pakistan. The trace statistics as well as the maximum eigenvalue statistics suggest that all the five markets are co-integrated and converge to the long-run equilibrium.

Table 4: Joint Cointegration Test Results Logged Wheat Market prices:

Equation Tested	Null Hypothesis	Alternate Hypothesis	Trace Statistics	Maximum Eigenvalue Statistics
LogHyd LogLahore- LogMultan LogPindi LogPeshawer	r=0 r≤1 r≤2 r≤3 r≤4	r≥1 r≥2 r≥3 r≥4 r≥5	171.08 (69.818)*** 111.80 (47.856)*** 60.962 (29.797)*** 15.973 (15.494)** 0.073 (3.841)	59.278 (33.876)*** 50.844 (27.584)*** 44.989 (21.131)*** 15.900 (14.264)** 0.073 (3.841)

Critical values at 95% confidence interval are in parenthesis.

Source: Author's calculations

Test results reveal that there are four co-integrating relationships in the joint co-integration analysis of all five wheat markets. As, Greene (2003) proves that there can be at most K-1 co-integration vectors in the joint co-integration test. Where, "K" indicates the number of variables in the system. This implies that there are four linear independent combinations of the variables; each combination is stationary. It also shows that there is at least one common stochastic trend.

4.3 Linear VECM results

The error Correction Model (ECM) was applied to estimate a long-term coefficient along with short-term dynamics. A linear VECM model results are presented in table 5. Results show a highly significant adjustment of prices in almost all the pairs of markets except the Hyderabad market. Adjustment to equilibrium from the Hyderabad market is slower as well as insignificant in some cases because this market is far away from the other four markets but still well connected to Lahore, Multan and Rawalpindi by means of transport and communication. Hence, there is no surprise in the quicker response of Lahore, Multan and Rawalpindi to Hyderabad.

Table 5: VECM Results of Wheat Markets of Pakistan

Logged Wheat Market Pairs	**Speed of Adjustment**	**Logged Wheat Market Pairs**	**Speed of Adjustment**
LogLahore- LogHyd	-0.183 *** 0.050	LogHyd- LogPindi	-0.085* 0.156***
LogLahore- LogMultan	-0.249*** 0.063	LogHyd- LogPeshawer	-0.033 0.095***
LogLahore- LogPindi	-0.171*** 0.177**	LogMultan- LogPeshawer	-0.037** 0.068***
LogLahore- LogPeshawer	-0.041* 0.060**	LogMultan- LogPindi	-0.047 0.246***
LogHyd- LogMultan	-0.090** 0.151***	LogPindi- LogPeshawer	-0.042* 0.057**

Note: *, ** and *** show the significance at 90%, 95% and 99%.

Source: Author's calculations

Due to the favorable infrastructure in Lahore and Rawalpindi and higher demand because of dense urban population in these areas, wheat trade to these markets from other parts of the country pushes them to adjust to the equilibrium quickly. Lahore, Multan and Rawalpindi are also well connected as well as close to each other as compared to the other markets under study. Multan is a bigger region in terms of production of wheat. Therefore, both the Lahore and Rawalpindi markets adjust quickly to Multan. Lahore is also one of the major markets in which multidirectional trade takes place. Apart from that, these results are from a linear VECM model without considering transaction costs. However, these results may differ when incorporating transaction costs into the threshold model.

4.4 Testing for thresholds

The Sup*LM* test for threshold co-integration clearly rejects the null hypothesis of linear co-integration against the alternate hypothesis of threshold co-integration at the 5% significance level. This holds true for seven out of ten pairs of different wheat market price series of Pakistan. While, for three pairs of price series namely Multan-Peshawar, Hyderabad-Peshawar and Lahore-Peshawar, the null hypothesis is rejected at the 10 % significance level. The Sup*LM* test results provide enough conclusive evidence of threshold co-integration to justify an application of the TVECM to the data. Estimates of Sup*LM* test with 1 lag and 5000 bootstrap replications on price series of wheat markets of Pakistan are provided in Table 6.

Table 6: Sup*LM* Test Results for Wheat Markets of Pakistan

Market Pairs	Cointegration Vector β	Threshold Parameter γ	Sup*LM* Test Value	Critical Value	*(P-Value)*
LogLahore-LogHyd	-1.006	-0.066	20.161	18.828	0.026
LogLahore-LogMultan	-0.982	0.139	20.414	19.334	0.031
LogLahore-LogPindi	-0.962	0.230	34.650	16.117	0.000
LogLahore-LogPeshawer	-0.997	0.018	16.865	17.464	0.063
LogHyd-LogMultan	-0.976	0.153	19.461	15.714	0.008
LogHyd-LogPindi	-0.954	0.179	26.348	15.554	0.000
LogHyd-LogPeshawer	-0.982	0.074	17.575	18.388	0.080
LogMultan-LogPeshawer	-0.978	0.077	27.437	18.868	0.000
LogMultan-LogPindi	-1.011	-0.112	17.415	18.558	0.084
LogPindi-LogPeshawer	-1.036	-0.272	18.503	15.252	0.012

Source: Author's calculations

4.5 Threshold Vector Error Correction Model

Table 7 presents the estimation results for the TVECM model with two thresholds (three regimes). The band between the two thresholds (regime 2 or middle regime) is the band of non-adjustment because deviations from the long-term equilibrium as compared to adjustment costs are so small that they will not cause an adjustment process of related prices within the band. As expected, the threshold error-correction model produced different results from the previous simple model. Co-integration clearly describes the long-run relationship among different wheat markets of Pakistan, and it can be seen from the threshold model that short-run adjustment to disequilibrium is somehow mixed. The results reveal that some market pairs show higher adjustment in both regimes, while others only indicate significant adjustment either in the upper or in the lower regime. Meyer (2004) referred to price adjustment due to disequilibrium in one direction or in one regime to be insignificant, considering the unidirectional trade flows or significant transaction costs. The adjustment parameters are higher and significant in most cases as compared to the results of the linear VECM, which shows that the threshold model describes the short-run adjustment in the prices as quicker and higher in magnitude.

Lahore (LHR) and Hyderabad (HYD) markets adjust quickly, when the shock is higher than the second threshold, which implies that prices adjust quickly when they are higher and adjustment is slow when the price difference is below the lower threshold. Lahore being the major production and consumption region in Punjab province of Pakistan forces other markets of Punjab, namely Rawalpindi (PINDI) and Multan (MLTN), to adjust quickly. These two markets are close to Lahore in terms of distance and are well connected through favorable infrastructure supporting transportation. This holds equally true in terms of information and communication. The linear VECM estimated a higher extent of adjustment for the Lahore market, which was somewhat surprising as Lahore market is considered the leader rather than the follower.

In most cases, higher and significant adjustments revealed by the estimation occur in the upper regime. When these deviations are above the second threshold and provide the opportunity for traders to take advantage of the arbitrage, then as expected, prices adjust quickly to form a new equilibrium.

Table 7: TVECM Results of Wheat Markets of Pakistan.

Market Pairs	Regimes	Speed of Adjustment	Constant	P_{1t-1}	P_{2t-1}
LLHR LHYD	Lower Regime	-0.098 (0.193) 0.124 (0.087)*	0.010 (0.056)* 0.012 (0.021)**	0.081 (0.318) -0.043 (0.579)	-0.039 (0.665) 0.270 (0.001)***
	Upper regime	-0.686 (0.001)*** -0.343 (0.099)*	0.036 (0.017)** 0.036 (0.013)**	0.029 (0.856) -0.101 (0.513)	0.011 (0.967) 0.349 (0.171)
LLHR LMLTN	Lower Regime	-0.324 (0.227) 0.651 (0.007)***	0.004 (0.752) 0.024 (0.022)**	-0.319 (0.100) -0.355 (0.041)**	0.221 (0.247) 0.346 (0.044)**
	Upper regime	0.188 (0.321) 0.369 (0.030)**	-0.023 (0.163) -0.029 (0.047)**	0.044 (0.735) 0.262 (0.024)**	0.237 (0.121) 0.195 (0.154)
LLHR LPINDI	Lower Regime	0.022 (0.801) 0.402 (2.9e-5)***	0.014 (0.004)*** 0.023 (3.2e-5)***	0.032 (0.750) -0.120 (0.268)	0.130 (0.170) 0.402 (0.000)***
	Upper regime	-0.089 (0.589) 0.156 (0.376)	0.004 (0.705) 0.004 (0.714)	0.222 (0.157) -0.152 (0.366)	0.159 (0.316) 0.283 (0.097)*
LLHR LPSHWR	Lower Regime	-0.029 (0.567) 0.094 (0.126)	0.008 (0.230) 0.007 (0.376)	0.270 (0.011)** 0.110 (0.395)	0.047 (0.522) 0.237 (0.008)***
	Upper regime	-0.292 (3.7e-5)*** -0.070 (0.404)	0.039 (3.4e-6)*** 0.018 (0.063)*	0.343 (0.000)*** 0.200 (0.086)*	0.009 (0.938) 0.252 (0.072)*
LHYD LMLTN	Lower Regime	-0.190 (0.490) 1.115 (1.0e-5)***	-0.004 (0.863) 0.097 (8.2e-6)***	-0.202 (0.375) 0.069 (0.738)	0.333 (0.026)** 0.248 (0.065)*
	Upper regime	-0.361 (0.042)** 0.004 (0.980)	0.032 (0.055)* 0.016 (0.286)	0.283 (0.006)*** 0.170 (0.067)*	-0.113 (0.374) 0.039 (0.732)
LHYD LPINDI	Lower Regime	-0.492 (0.001)*** -0.263 (0.146)	-0.015 (0.090)* -0.022 (0.033)**	0.284 (0.064)* 0.151 (0.399)	0.023 (0.838) 0.094 (0.474)
	Upper regime	-0.118 (0.298) 0.237 (0.075)*	0.017 (0.212) -0.013 (0.423)	-0.021 (0.870) -0.010 (0.949)	-0.029 (0.778) 0.044 (0.713)
LHYD LPSHWR	Lower Regime	-0.016 (0.772) 0.250 (0.000)***	0.007 (0.145) 0.011 (0.046)**	0.181 (0.118) -0.366 (0.008)***	0.036 (0.630) 0.569 (0.000)***
	Upper regime	-0.310 (7.4e-5)*** -0.125 (0.173)	0.045 (4.6e-6)*** 0.029 (0.014)**	0.120 (0.183) 0.189(0.077)*	-0.043 (0.683) 0.135 (0.287)
LMLTN LPINDI	Lower Regime	-0.283 (0.175) 0.801 (0.000)***	-0.004 (0.768) 0.057 (0.001)**	0.338 (0.032)** 0.292 (0.104)	0.121 (0.382) 0.240 (0.130)
	Upper regime	0.043 (0.699) 0.369 (0.004)***	0.006 (0.452) -0.003 (0.779)	0.041 (0.784) -0.178 (0.290)	0.081 (0.554) 0.123 (0.428)
LMLTN LPSHWR	Lower Regime	-0.099 (0.003)*** 0.031 (0.490)	-0.002 (0.627) 0.002 (0.725)	0.366 (2.4e-5)*** -0.013 (0.910)	-0.078 (0.164) 0.192 (0.009)**
	Upper regime	-0.235 (0.012)** -0.213 (0.082)*	0.030 (0.009)*** 0.045 (0.003)***	0.366 (0.000)*** 0.222 (0.121)	-0.105 (0. 343) -0.049 (0.734)
LPINDI LPSHWR	Lower Regime	-0.126 (0.012)* 0.034 (0.523)	-0.011 (0.164) -0.001 (0.992)	0.249 (0.007)*** -0.079 (0.414)	0.020 (0.819) 0.351 (0.000)***
	Upper regime	-0.207 (0.009)*** -0.041 (0.630)	0.018 (0.002)*** 0.015 (0.017)**	0.142 (0.201) 0.054 (0.644)	0.147 (0.230) 0.104 (0.421)

Source: Author's calculations

5 Conclusion

The aim of this study was to provide empirical evidence of market integration, and to assess the degree of market integration in the wheat markets of Pakistan. This was attempted using a dynamic model, which incorporates unobserved transaction costs. In the past, wheat markets of Pakistan have been analyzed using only co-integration techniques. The contribution of this paper is to understand the integration of Pakistan's wheat market through the application of the TVECM with three regimes to take into account the effect of transaction costs. As discussed earlier, the TVECM enables us to incorporate the unobserved/unobservable transaction costs as a neutral band of no adjustment in the middle regime. The results agree largely with the existing literature and conclude that the wheat markets of Pakistan are very well integrated in the long-run. However, short-run adjustments only occur when price deviates above the threshold. Further, non-linear threshold co-integration suggests higher adjustment as compared to linear VECM, where the role of transaction costs is ignored. Higher adjustment coefficients obtained from the application of threshold model raises the same question of justification for government interventions, as raised earlier by Mushtaque *et al.* (2007), Dorosh and Salam (2008) and some others. Wheat being the major staple food has been center of the extensive and costly government interventions, because its availability and access to the whole population is linked with food security, which is a major concern for Pakistan. Estimated results, based on the different wheat markets of Pakistan, reveal that wheat markets are well integrated, which ultimately leaves the impression of efficient market functioning. Hence, the expensive interventions of the government should be reduced and private sector should be allowed to trade wheat within the country, and invest in the wheat storage and transportation, which will not only reduce the burden of the economy but will also increase the effectiveness of arbitrage and the efficiency of market functioning.

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